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## SOME APPLICATIONS OF REMOTE SENSING TECHNOLOGY FOR INTERNATIONAL FUNDING AGENCIES

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Inter-American Development Bank

Problems such as the complete inventory of the resources of the globe, the preservation of scarce resources and their rational utilization can only be solved today on an international level. There exists a worldwide concern for development which is preferably conceived in terms of global economic stability and steady rate of growth. There also exists a worldwide concern for technology transfer, a principal process by which the emerging nations try to improve their conditions.

International agencies such as the International Bank for Reconstruction and Development (IBRD or World Bank) and the Inter-American Development Bank (IDB), directly involved in seeking solutions to those problems, are using remote sensing systems in development projects which they finance every year around the world.<sup>4,5</sup>

The purpose of this paper is to examine the various factors which are making these techniques of increasing interest for the international development organizations, to assess their advantages and limitations in development projects, and to look at their future roles in the activities of these agencies.

### I. IDB AND ECONOMIC DEVELOPMENT IN LATIN AMERICA

The Inter-American Development Bank was established in 1959, with nineteen Latin American countries and the United States as charter members. Today, the membership of the Bank includes twenty five western hemisphere nations and twelve non regional countries -ten from Europe plus Japan and Israel. The Bank's subscribed capital stock currently totals \$7,464 million, of which the U.S. share is 36 per cent.<sup>10</sup>

Since the Bank opened in October 1960, its lending support for Latin American economic and social development projects has exceeded the \$10 billion mark as of 31 December 1976. The total value of these projects exceeds \$41 billion. The Bank's lending from 1961 through 1975 represents

about 40 per cent of the total development financing for Latin America from the international development banks and the Agency for International Development (AID). In 1976 alone, the IDB accounted for 49 per cent of official external capital for Latin America.<sup>10</sup> During the 1975-1976 period, its total financial resources had grown to about \$18 billion from an estimated resource base of \$1 billion in 1960.<sup>5</sup>

The IDB serves as administrator for several special funds provided by member and non-member countries. But, its major financing operations are carried out through two lending windows. One is the capital window which makes loans at near market terms and the second is the Fund for Special Operations (FSO) which is used for concessional loans. Capital loans are made at an interest rate of 8.35 per cent with maturities ranging from 15-30 years. The FSO enables the Bank to provide concessional resources to its least developed countries and the loans are made at a rate of 1 to 4 per cent and maturities of 20-40 years, depending on the relative economic strength of the borrowing country and the type of project financed. The Bank's capital lending is financed from the paid-in capital subscriptions of its members and from the proceeds of borrowings in the international capital markets.<sup>10</sup>

Projects submitted to the Bank for financing are prepared by the country seeking a loan. To date, the funds approved by IDB Board of Executive Directors have been used by the borrowers to finance: (1) Agriculture, Forestry and Fishing; (2) Industry and Mining; (3) Transportation and communications; (4) Electric Power; (5) Sanitation; (6) Housing and Urban Development; (7) Education; (8) Tourism; (9) Preinvestment and Technical Cooperation; and (10) Export Financing.

### II. REMOTE SENSING IN THE DEVELOPMENT PROCESS

First of all, what is development? Secondly, what are the basis for development projects? And thirdly, where does remote sensing fit into these activities?

Development is a form of change. It is a dynamic process, at times ambiguous, and may generate satisfaction and disenchantment.<sup>18</sup> Development is an elusive concept which is not purely creation, it is evolution. In the context of designing projects, development starts with people and their education, organization and discipline. Without these three all resources remain latent, untapped potential.<sup>24</sup> The relative presence or absence of these three factors determines to a great extent whether or not a country and its people belong to the developed and developing nations of the world.

Development projects are prepared to meet specific objectives.<sup>19</sup> Those objectives are conditioned by economic, social and political factors.<sup>12</sup> Each development project is characterized by a specific framework, which, itself, depends upon: (1) project size and location; (2) organizational structure and execution terms; (3) market possibilities; (4) engineering considerations; (5) project cost; (6) budgetary terms; and (7) financial resources.

The countries seeking financial assistance from the Bank must be able to design projects capable of insuring that economic development will be brought forward. This must be clearly demonstrated by the borrower through the mobilization of internal resources which will be injected into the various phases of a development project. There are four broad phases which can be labeled "the project cycle". These are: (1) preparation; (2) analysis; (3) implementation; and (4) appraisal.

The preparation phase of a development project, say agriculture or mining, dictates that natural resources -renewable and non renewable- be first identified. This must be accomplished through a comprehensive resource inventory program. Investigations are required to identify these resources and the results of these investigations are usually discussed in sectorial studies which constitute a fundamental base of project. There, remote sensing offers definite advantages in identifying resources over the utilization of many conventional techniques.<sup>1</sup>

The results of various projects in which computer aided analysis techniques were used strongly support the fact that remote sensing from high flying aircrafts such as Landsat is effective in providing timely reliable information concerning the resource base on which projects are planned.<sup>16</sup> Other simple, inexpensive visual interpretation techniques have been found to produce useful information in this phase of the project cycle. But, the arguments against or in favor of digital and visual analysis of remotely sensed data are directly related to the scope and objectives of the project.

The analysis phase begins once the project is

planned and financed. It may deal with an examination of changes in the project resource base or an assessment of potential benefits or problems associated with the utilization of the resources of the project area. This phase may be carried out in a gradual sequence either before or during the implementation phase, and varies from one project to another. The technical analysis must be thorough and precise. It is done periodically by the project specialists and other experts whose main responsibility consists of supervising the development of the critical phases of the project to insure that its technical, financial, socio-economic, political and legal aspects are being implemented satisfactorily in accordance with the regulations of the Bank.

The results of a project carried out at the Laboratory for Applications of Remote Sensing (LARS), Purdue University, for the Bank and the Government of Costa Rica demonstrated that digital analysis of Landsat data can be used efficiently and effectively to analyze certain phases of agricultural projects.<sup>9</sup>

The implementation phase varies in duration from two and a half to four years for an industrial project or from four to five years for most irrigation projects. The role of remote sensing may be more limited in this phase of the project cycle than in the other ones mentioned so far. This is due to the nature of the activities pertaining to the implementation phase of projects which may deal with the number of industries or schools built, hardware installed, highways completed, irrigation canals, reservoirs and dams constructed.

However, if the implementation phase deals with the allocation and management of large volume of resource information such as in national or regional land use projects, then, remote sensing can play specific functions susceptible of speeding up the completion of such projects.

The last phase of the project cycle is the project appraisal which is aimed at an assessment of one or several parameters related to the project development. They may represent forested vis-a-vis deforested areas, formation of saline soils and other drainage related problems in areas where irrigation projects are being carried out. Whether or not remote sensing would be very useful to this phase depends on the factors being appraised. The appraisal phase inevitably includes an economic and financial assessment of the whole project.

The four project phases thus far enumerated are followed by an evaluation phase which considers the technical, managerial and administrative, organizational, commercial, financial and economic aspects of projects. Not all of these are equally applicable to many projects, particularly in the agricultural sector, but all need to be considered.<sup>14</sup>

### III. REMOTE SENSING IN IDB ACTIVITIES

The IDB through its preinvestment loans which have the main purpose of financing land surveys, resources inventories, engineering studies and others can help its member countries apply remote sensing techniques in the identification of certain renewable resources, vegetative cover, extent of cultivation of one or several crops, land use patterns and others, and non renewable resources such as geomorphological characteristics associated with mineral deposits or major earthquake zones.

The Bank has a great interest in technology transfer whether the technology is advanced or intermediate. Technology transfer is one of the most challenging areas since the control of most of the existing technology rests with the private sector rather than with governments. Therefore, such technology is aimed at the biggest trade markets where the needs are different from those of many Third World nations.

Remote sensing development through technology transfer must be a reciprocal process. It is not "something" that can be handed by one group of nations to another group of nations. Reciprocal obligations and actions are required by industrial and developing countries to insure that remote sensing know-how be adequately transferred and adapted to the needs and interest of the developing nations.<sup>2,23</sup>

Remote sensing technology transfer starts with a clear understanding of its terminology which controls different levels of communication, associated with research and data handling, analysis, classification, standardization, and dissemination. The documentary basis of terminology in its technical aspect is one of selection storage and retrieval of information.<sup>6</sup> It must provide clarity and flexibility between the scientist's conceptual views of a science and the users desire to understand what it is.

The Bank, fully aware of countless cases of disruptive methods of technology transfer, has financed, since 1975, remote sensing activities pertaining to staff training at EROS Data Center, Sioux Falls, South Dakota and at LARS, Purdue University, West Lafayette, Indiana. The Bank also financed the Costa Rican case study previously mentioned which served as a vehicle to train Costa Rican scientists in the digital analysis of Landsat data. The total cost of these programs is estimated around \$50,000. One of the fundamental objectives of these training projects is to enable scientists and policy makers from IDB's member countries to become familiar with the advantages and limitations of various photographic sensors, hardware and software, so that they can themselves select the most pragmatic

and efficient approach for using remote sensing techniques in their countries.

IDB places a heavy emphasis on the development of agriculture in Latin America, and, consequently, supports the effort of its member countries to utilize any tool, technology or strategy aimed at boosting agricultural production. Landsat and the Geostationary Operational Environmental Satellites (GOES) are viewed as tools which can permit the developing countries to rapidly identify, quantify and monitor on a cost minimizing basis their natural resources as a fundamental criterion for project planning.<sup>21</sup> There lies one of the major interest of the international funding agencies in financing projects in which remote sensing techniques are used. Research project such as the Large Area Crop Inventory Experiment (LACIE), if successful in the long run through the establishment of an operational system of crop forecasting, could be of special interest for agricultural development projects.

Negotiations are underway between the Bank and the Central American countries for the financing of a resource inventory of the region. This project which is expected to be carried out during the 1977-78 period will involve scientists from Central America, the United States Geological Survey (USGS) and LARS-Purdue University. This program will be the first remote sensing project financed by the Bank on a regional basis.

### IV. A LOOK TO THE FUTURE

The progress achieved in the past ten years in the digital analysis of remotely sensed data is undoubtedly impressive. It is rather difficult to speculate on the scope and magnitude of future technological breakthroughs in the field of remote sensing. It is even more difficult to anticipate at this stage what the impact of these techniques will be on the development of future generations in developed and developing nations.

Presently, about 14 developed and 36 developing countries are participating in NASA's earth resources investigation programs.<sup>22</sup> Argentina, Chile and Zaire have signed agreement with NASA to build Landsat receiver processor stations. Countries such as Brazil, Canada and Italy which operate Landsat ground stations are charged by NASA \$200,000 per station per year. The EROS Data Center has already sold Landsat data to some 130 countries. Since the launch of Landsat-1 in July 1972, these countries have spent or committed close to \$100 million for hardware services and data related to Landsat, approximately 80% of this has been or will be spent in the United States.<sup>13</sup> This represents a positive influence on the United States balance of payments, and therefore, policy makers should be more receptive not only towards the Landsat program but also in a broader sense toward foreign aid.

Investigations will be required to systematically assess the impact of Landsat and other earth resources technology satellites on the economies of the developing countries. Studies conducted in Bolivia, Brazil, Sudan and other developing nations point out examples of substantial benefits resulting from the utilization of remote sensing systems.<sup>7,8,11</sup>

The international funding agencies, particularly the World Bank and the Inter-American Development Bank, are fully aware of the practical advantages of such technologies and are looking favorably at the promises which the Landsat follow-on program holds for their member countries in the 1980's. The World Bank, for instance, has financed land use studies with Landsat data in the Orissa Province, India, in Upper Volta and Burma.

One of the limitations of the current Landsat program is the satellite resolution whose smallest resolving power, roughly equivalent to 0.5 hectare, is known as a pixel. In most developing nations where subsistence farming is prevalent in agricultural regions having an average farm size of 0.2-0.4 hectare, agricultural features and thus their spectral characteristics cannot be adequately mapped with Landsat. Even when the field sizes are larger than 0.5 hectare, the cropping systems (crop calendar) inherent to the tropical areas make it often difficult to analyze the spectral data satisfactorily. However, one advantage might come from the spatial resolution of Landsat-D which is expected to be 30 to 40 meters in the four reflective channels and approximately 120 meters in the thermal band. This means that agricultural fields smaller than 0.5 hectare will be able to have their reflective properties or reflectance values "pick up" by Landsat-D Multispectral Scanner (MSS) and Thematic Mapper (TM), thereby facilitating rapid quantification through digital analysis of these resources required to develop agricultural projects.<sup>20</sup> It will also become necessary to elaborate adequate schemes of data acquisition, processing and dissemination, so that remote sensing techniques may be fully integrated into current methodologies of project preparation, analysis, implementation and appraisal.

While problems related to spatial resolution, spectral range, scanning frequency, analytical capabilities and data dissemination are being investigated, a number of questions with potential socio-economic implications will need to be answered, for instance: (1) should all remote sensing systems be controlled by private or government agencies? (2) Who will be the major beneficiaries of a global information system for earth resources? (3) Should a country's operational system be financed exclusively by government or private capital?<sup>17</sup> These questions have certainly been raised in the past and will

be raised in the future with respect to the development of other technologies.

## V. SUMMARY

Remote sensing technology cuts across a broad range of disciplines closely related to the development activities of the international funding agencies. It can be used effectively and on a cost minimizing basis by the member countries of the Inter-American Development Bank to identify and quantify natural resources necessary to prepare projects. It can also be used by the Bank to analyze and appraise certain aspects of development projects financed with its resources. The Bank is financing training programs aimed at insuring adequate and progressive transfer of remote sensing technology from developed to developing countries. The effectiveness of technology transfer is related to a better environment of understanding, confidence and cooperation among developing and industrial nations.

Although the Landsat program is still experimental and that many research and development issues related to its follow-on aspects are not clearly resolved and defined yet, the future, however, looks very promising for the utilization of such remotely sensed data in development projects. In areas where cloud cover seems to be constantly a problem during most of the year such as in the Amazon jungle, radar techniques and other remote sensing systems may be the most relevant approach for identifying resources required to develop projects.<sup>15</sup>

It is almost certain that remote sensing systems in developing nations will be owned and controlled by the government. The question arises as to how to insure access to information unrestricted by non-economic considerations. It is perhaps appropriate to conclude by mentioning that if Paul Valery were asked to comment on the potential and socio-political intricacies of remote sensing today, he could have probably replied: "L'espece humaine s'est engagée dans une immense aventure". (The human race is engaged in a huge adventure).

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\*The opinions expressed are those of the author, and do not necessarily reflect those of this international funding agency.